TIME OF DEVELOPMENT OF THE DIFFERENT SEXUAL FORMS IN *DROSOPHILA MELANOGASTER*

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In the progeny of a triploid female crossed to a normal diploid male there appear six different sexual types. These are the diploid females and males, triploid females, intersexes, and the two kinds of so-called supersexes, namely superfemales and supermales. As shown by Bridges (1921, 1922) these sexual types are due to variations in the ratio between the number of X-chromosomes and the number of sets of autosomes present in cells of a given individual. According to Bridges the different sexual types have the following ratios:

	Number of X-chromosomes	Number of Sets of Autosomes	Ratio
Superfemale	3	2	1.50
Diploid female	2	2	1.00
Triploid female	3	3	1.00
Intersex	2	3	.67
Male	1	2	.50
Supermale	1	3	.33

Most of the characters of the flies change in this series of sexual types hand in hand with the change of the sex-determining ratio. There are, however, some characters of the flies which seem to be independent of the sex-determining ratio. Among such characters may be listed the size of the cells, which is correlated with the amount of chromosomal material present in their nuclei (Dobzhansky, 1929). Another character of this kind is the length of the development period, to the study of which the present paper is devoted.

The length of the development period has been studied previously in only the diploid males and females (Bonnier, 1926). According to Bonnier, the development of males takes a slightly longer time than that of females. At 25° the development of a female takes 227.98 hours on the average, and the development of a male 232.24 hours. At 30° the corresponding figures are 178.10 and 187.63 hours.

The technique of the present study was as follows. Batches of from twenty to thirty wild-type triploid females were kept together

with an approximately equal number of males for two days to ensure fertilization. The flies were then transferred to the ordinary culture-bottles provided with a standard amount of food, but without filter-paper, which is regularly placed in each culture-bottle. Here the flies were allowed to lay eggs during a two-hour period, and after that were again transferred to fresh bottles without paper, and again allowed to lay eggs during another two-hour period. The above procedure was repeated from five to six times with each batch of flies. All the transfers from bottle to bottle were performed without etherization of the flies, because females of *Drosophila* are known to interrupt the egg-laying for several hours after being etherized. The bottles with eggs secured by this method were placed in an incubator and kept at 27°. As soon as the mature flies began to emerge, bottles were examined every two hours. In young flies the determination of the sexual type is sometimes difficult; in cases of doubt, flies were kept alive until the sex could be determined with certainty. Only those bottles which produced more than 20 but less than 60 flies were taken into account (the average number of flies per bottle was 38.5). All other bottles were

TABLE I

Time of Emerging from the Pupæ

Time in Hours	Diploid Females	Triploid Females	Males	Super-females	Inter-sexes	Super-males
183	1	—	—	—	—	—
185	14	2	—	—	—	—
187	19	3	2	—	—	—
189	16	4	2	—	—	—
191	35	6	6	—	—	—
193	25	3	2	—	—	—
195	23	—	5	—	—	—
197	25	2	2	—	—	—
199	26	—	9	—	—	—
201	29	5	8	—	—	—
203	29	2	4	—	—	—
205	29	7	26	—	—	—
207	21	6	10	—	—	—
209	22	11	9	—	—	—
211	7	7	7	—	—	—
213	7	6	5	—	—	—
215	4	1	2	—	—	—
217	1	—	1	—	—	—
219	1	—	2	—	—	—
221	—	—	—	—	—	—
223	—	—	—	—	1	—
225	1	1	—	—	1	—
227	—	2	—	—	—	—

TABLE I (*Continued*)

Time in Hours	Diploid Females	Triploid Females	Males	Super-females	Inter-sexes	Super-males
229	1	—	—	—	2	—
231	—	—	—	—	1	—
233	—	—	1	—	3	—
235	5	1	3	—	5	—
237	—	—	—	—	2	—
239	—	—	—	—	13	—
241	—	—	—	—	12	—
243	—	—	—	—	10	—
245	—	—	—	—	8	—
247	—	—	—	—	7	—
249	—	—	—	1	6	—
251	—	—	1	—	9	1
253	—	—	—	1	12	—
255	—	—	—	—	24	—
257	—	—	—	—	18	2
259	—	—	—	—	22	—
261	—	—	—	—	20	1
263	—	—	—	—	10	1
265	—	—	—	—	11	1
267	—	—	—	—	5	1
269	—	—	—	—	4	—
271	—	—	—	—	3	2
273	—	—	—	—	3	1
275	—	—	—	—	2	1
277	—	—	—	—	2	1
279	—	—	—	—	4	—
281	—	—	—	—	6	—
283	—	—	—	—	4	—
285	—	—	—	—	1	—
287	—	—	—	—	—	3
289	—	—	—	—	2	1
291	—	—	—	—	1	—
293	—	—	—	—	—	—
295	—	—	—	—	—	—
297	—	—	—	—	—	1
Total	341	69	107	2	234	17

discarded, since overcrowding of food with larvæ might slow down the development, especially of the weaker types, and bottles producing too few flies usually have the food in poor condition.

The technique just described gives a reasonable degree of certainty that all the flies developed under similar external conditions and that the length of the development period of each individual fly is determined with an error not exceeding ± 1 hour. The material gathered in this way is presented in Table I. As seen from this table, 770 flies were obtained. Among them there were 44.3 per cent diploid females,

9.0 per cent triploid females, 13.9 per cent males, 30.4 per cent intersexes, 0.3 per cent superfemales and 2.2 per cent supermales. This is about the normal frequency of the different sexual types in the progeny of triploid females. In another experiment, in which offspring were obtained from individual triploid females kept in the bottles until their progeny appeared, there were 50.8 per cent diploid females, 6.4 per cent triploid females, 7.9 per cent males, 32.3 per cent intersexes, 0.2 per cent superfemales and 2.4 per cent supermales. (The total number of flies in this experiment equals 8796 flies; the average number of flies per bottle equals 71.6).

Consideration of the data presented in Table I shows at once that the different sexual types do not develop equally fast. The six known

TABLE II

The Length of the Development Period (in hours) of the Different Sexual Types

	Mean Value	σ	C	n
Diploid females	199.24 ± .49	9.12	4.5	341
Triploid females	203.83 ± 1.29	10.72	5.3	69
Males	205.20 ± .98	10.08	4.9	107
Intersexes	255.76 ± .82	12.52	4.9	234
Superfemales	251.00	—	—	2
Supermales	272.72 ± 3.12	12.90	4.7	17

types may be divided roughly into two groups. The development of the diploid and triploid females and males takes from 185 to 219 hours, and only a few individuals require longer than that period. On the other hand, intersexes, superfemales and supermales begin to hatch after 220 hours. That is to say, there exists a short period of time when scarcely any flies emerge in the cultures.

The results of the statistical treatment of the material presented in Table I are shown in Table II. The development of the diploid females takes the shortest time as compared with other sexual types. The development of males takes 5.96 ± 1.05 hours longer than that of the diploid females. This difference is statistically significant and is approximately equal to that obtained by Bonnier in his experiments. The absolute values for the length of the development of diploid females and males are also in good agreement with Bonnier's data (one must, of course, take into account that the temperature used in the present experiments is intermediate between the two temperatures used by Bonnier).

The figure obtained for the length of the development of triploid

females is intermediate between the figures obtained for diploid females and males, but the differences are not statistically significant in either case. It may be concluded that the development of the triploid females takes approximately as much time as the development of the diploid females and males, and far less than the development of the intersexes and the supersexes.

The development of the intersexes takes $255.76 \pm .82$ hours on the average. This figure is unquestionably different from those obtained for females and males. Although the figure for the superfemales (251 hours) is based only on two individuals, it may be taken for certain that the length of the development of the superfemales is of the same order of magnitude as that of the intersexes and the supermales. This has been proved in a different experiment in which superfemales were obtained in greater number together with diploid females and males (this experiment deals with the progeny of attached-X females crossed to normal males). In this experiment superfemales appeared in the bottles only in the later counts, when the number of diploid females and males hatching in a given interval of time was already declining. The length of the development of the supermales (Table II) is significantly greater than that of the intersexes. That is to say, the supermales develop more slowly than any of the other sexual types known.

It may be concluded that the length of time of development does not show a correlation with the ratio between the number of X-chromosomes and the number of sets of autosomes, the ratio which is known to determine the sexual type. The types studied may be divided into two groups: the balanced and the unbalanced types. The balanced types are those which have the sex-determining ratio equal to that observed in diploid females or males. Beside the diploid females and males only the triploid females belong to this group. Their development takes a relatively short time. The unbalanced types are the intersexes and the supersexes; their development takes a longer time.

Summary

1. The different sexual types known in *Drosophila* are characterized by different lengths of their development periods. Diploid females develop more quickly and supermales develop more slowly than the other sexual types, which are intermediate between these two extremes (see Table II).

2. There is observed no correlation between the length of development and the sex-determining ratio (*i.e.*, the ratio between the number of X-chromosomes and the number of sets of autosomes present in the cells of a given individual).

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